

The effect of eye movements on craving, pleasantness and vividness in smokers

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Abstract

The presence of craving is an important factor in continuing smoking. Following the Elaborated Intrusion (EI) theory of Desire, craving is effective through the formation of smoking-related mental images. In the current study, craving was generated through the use of a future personal smoking-related image. Eye movements were observed in accordance with the Eye Movement Desensitization Reprocessing (EMDR) intervention. The effect of these eye movements on craving was investigated. In addition, the effect of eye movements on the pleasantness and vividness of the image was examined. 36 participants took part in a within-subjects design with repeated measures. In line with expectations, perceived craving decreased immediately after the experimental condition (eye movements) was experienced. This decrease was not found in the control condition (fixation on a plain wall). After recall of the smoking-related image, the extra measurement showed that the decrease was temporary. Contrary to expectations, the degree of pleasantness and vividness did not decrease after eye movements. In conclusion, the eye movements were found to have only a temporary effect on craving for cigarettes, and did not result in desensitization of the pleasantness and vividness of the personal smoking-related images.

Keywords: craving; smoking; EI-theory; eye movement; EMDR

Introduction

In the Netherlands, about 20,000 people die yearly from diseases caused by smoking (STIVORO, 2011a; Nationaal Kompas, 2011a). Smoking is the leading avoidable cause of death in developed countries (Shiffman et al., 2008). It increases the risk of lung cancer, asthma and COPD, head and neck cancer, and esophageal cancer. Moreover, smoking is a risk factor for stroke and cardiovascular disease. These health risks indicate how important it is to quit smoking. The sooner people quit smoking, the more the risk of early death decreases (Nationaal Kompas, 2011b). However, quitting smoking is difficult. Only one out of seven smokers is

successful in doing so, according to statistics from 2009 (STIVORO, 2011b).

The presence of craving is one of the main reasons why people continue their smoking habits, and why they experience a relapse when they attempt to quit (May, Andrade, Panabokke & Kavanagh, 2010, Carter et al., 2008, Brody et al., 2004). Smokers automatically experience craving after several hours of abstinence. A significantly higher level of craving is experienced right before smoking, and the craving gradually subsides when the cigarette is smoked. This suggests that people smoke to suppress craving (Carter, 2008; Brody et al., 2004). Craving was the best predictor of relapse among smoking addicts that was identified in the Diagnostic and Statistical Manual of

Mental Disorders-IV (DSM-IV) (Swan, Ward & Jack, 1996). Research by Allen, Bade, Hatsukami and Center (2008) also showed that craving peaks in the days before relapse. Craving is defined as an emotionally charged mental state where an urge or desire to engage in a particular behavior is maintained in focal attention. Craving unconsciously arises after a period of withdrawal (May et al., 2010).

In the Elaborated Intrusion theory of Desire (EI theory; Kavanagh, Andrade & May, 2005), the power of craving for substances is ascribed to mental images formed of the particular substance. It concerns a cycle in which smoking-related cues from the environment penetrate into the focus of attention, which is followed by retrieving relevant information from memory about smoking. Information regarding the smell, taste and shape of tobacco are combined into a mental image, which the individual experiences as a reward. This feeling of reward is only temporary. Feelings of distress are experienced when the individual notices a discrepancy between the desired state and the actual current state, the authors say. Because of this distress, smokers search for more relevant information about smoking in order to create more powerful mental imagery. This imagery is rewarding in the short term, but worsens the long-term mood. For example, when a smoker can well imagine what the cigarette looks like, how it tastes, where he or she is at the time of smoking, and what the effect of nicotine is on the individual, the mental image is detailed. If an individual is currently not smoking, there is a large discrepancy, and such detailed imagery results in strong craving (May et al., 2010). This intrusive and automatically occurring imagery, and its associated craving, are an important focus of intervention.

Current interventions focusing on coping with craving or reducing craving during smoking cessation can be divided

into two groups. Pharmacological therapies such as nicotine replacement and bupropion work well to reduce craving (Ray, Schnoll & Lerman, 2009). Both individual and behavioral group therapy are also effective in reducing craving (Hajek, Stead, West, Jarvis & Lancaster, 2009; Ray, Schnoll & Lerman, 2009). The combination of behavioral therapy and pharmacotherapy are additive in increasing successful quit attempts (Silagy, Lancaster, Stead, Mant & Fowler, 2004). This combination of therapies is considered the gold standard for treatment (Shiffman et al., 2008). A study by Hughes, Keely and Naud (2003) showed that only three to five percent of people who try to quit without treatment remain abstinent after one year. This quitting rate increases by eight percent when behavior therapy is combined with pharmacological therapy (Ray, Schnoll & Lerman, 2009). These statistics indicate that, despite improvements in behavioral and pharmacological interventions, most attempts to quit smoking end in relapse (Shiffman & Waters, 2004). Given the health risks, the development of interventions which will increase long-term abstinence is necessary.

A potential intervention to reduce craving is Eye Movement Desensitization and Reprocessing (EMDR). This intervention is aimed at desensitization of mental images. EMDR was introduced about twenty years ago as a treatment for posttraumatic stress disorder (PTSD) (Gunter & Bodner, 2008; van den Hout et al., 2010). When starting EMDR, the patient has to recall an unpleasant memory of his or her trauma. During recall of this memory, the client is instructed to follow the horizontal hand movements made by the therapist. This is done in sets of 20 back-and-forth movements. After each set of eye movements, the patient is asked to report current cognitions and emotions. Sets are repeated until the lowest point of vividness and emotionality is achieved

(Shapiro, 2002). Over the past 20 years, extensive research has been conducted on the effectiveness of this method to treat PTSD symptoms. Effectiveness has been demonstrated in several meta-analyses (Van Etten & Taylor, 1998) and appears at least as effective as cognitive behavioral therapy (Bisson et al., 2007; Davidson & Parker, 2001). The American Psychiatric Association (2004) and the Dutch Multidisciplinary Guidelines for Anxiety Disorders (Landelijke stuurgroep, 2003) even rated this as one of the best interventions for treating PTSD symptoms.

So far, no consensus has been reached on the exact mechanisms by which EMDR works. A possible explanation is given in terms of a working memory account, which states that EMDR reduces vividness and emotionality of a traumatic memory by taxing the working memory (WM). This theory currently has the most empirical support (Gunter & Bodner, 2008). The WM consists of three parts: the central executive, the phonological loop and the visuospatial sketchpad (VSSP) (Baddeley, 1986). The central executive regulates complex cognitive tasks such as planning, problem solving, activating memories and dividing attention. The phonological loop processes verbal information and the VSSP processes visuospatial information. The assumption is that eye movements and retention of unpleasant images during EMDR both require capacity of the WM. Due to limited capacity of the WM, both have to compete with one another to stay in the focus of attention. This results in lower vividness and emotionality being associated with the unpleasant memory (van den Hout et al., 2011; Gunter & Bodner, 2008). The conventional theory of Baddeley (1986) is based on modality specificity, which involves verbal tasks engaging the capacity of the phonological loop and the visual tasks to claim the VSSP. According to this view, EMDR is effective through the VSSP. Gunter and Bodner (2008) found a

general effect on the central executive in addition to a modality-specific effect. When a memory from the VSSP is recalled, both interventions (by loading the VSSP as well as by loading the phonological loop) are effective in reducing the vividness and emotionality of the memory. Furthermore, participants with high levels of central executive functioning have experienced fewer gains from these distraction tasks than participants with lower levels of cognitive functioning. This suggests that the central executive is the variable most centrally involved in reducing emotionality and vividness of a memory. Recent research conducted by van den Hout et al. (2011) reported similar findings, which provides further support for the notion that the load of the central executive is responsible for the effectiveness of EMDR.

In the present study, and based on the previously mentioned EI-theory, EMDR was seen as a promising new intervention in reducing craving to smoke. In both this theory and EMDR, there is a central role for mental representations that are formed by information stored in memory. By generating craving, mental images are formed with respect to a desired situation with regard to smoking. The aim of EMDR is to reduce the pleasantness and vividness of the image through the use of eye movements, in order to permanently reduce the craving for cigarettes. Possible support for the use of eye movements in reducing craving is provided in a study by May et al. (2010). After a period of abstinence, the participants were asked to read a craving-inducing, lively script and to visualize this. Subsequently, they were asked to imagine a series of visual scenes. These competing visual stimuli (including a rose garden, a birthday cake and dawn) caused a significant decrease in craving for the experimental as compared to the control group. Research that focused specifically on the effect of eye movements on craving for substances was

conducted by Hase, Schallmayer and Sack (2008). Chronic alcohol dependent patients were assigned to either the normal detoxification treatment, or to the usual treatment plus two EMDR sessions of one hour each. In the experimental condition with eye movements, the participants were asked to mentally represent an unpleasant memory of a relapse or a moment of strong craving. After that, an attempt was made to desensitize the mental representation through eye movements. Craving was significantly decreased in participants in the experimental condition, both immediately after treatment and one month following completion of treatment. Participants who only received the usual detoxification treatment showed no significant decrease in craving immediately after treatment, or one month following treatment. The scores for the two measurements differed significantly between the conditions (Hase, Schallmayer & Sack, 2008). There are two important discrepancies between EMDR applied to PTSD symptoms and EMDR applied to a smoking addiction. With smoking addiction, the affective charge of the desired mental image is a positive image, while the image of trauma contains a negative memory. However, research has pointed out that, after the application of EMDR, positive memory images also decrease in vividness and emotionality (van den Hout, Muris, Salemink & Kindt, 2001; Engelhard, Uijen & van den Hout, 2010). In addition, the mental image of the smoking addiction involves a mental representation in the future, instead of a memory. A study conducted by Engelhard, van den Hout, Jansen and van der Beek (2010) showed that the vividness of a flash forward was reduced after the application of EMDR. In conclusion, we presume that, to a large extent, craving is defined by positive images about the future. The application of eye movements in attenuating mental representations is originally designed to desensitize negative

images of the past, but also proves to be effective in the desensitization of positive images and images relating to the future. The desensitization of a combination of both (i.e., a positive flash forward) has not yet been investigated.

The aim of the present study was to determine the effect of EMDR on craving for cigarettes. Participants were asked to provide personalized smoking-related imagery as the starting point for both the sets of eye movements and the control condition with fixations. Measurements were recorded both immediately after the eye movements or fixations, and then afterward when recalling the original image. The purpose of these comparative measurements was to determine whether any decline in craving after eye movements is relatively permanent and if the original image has become less vivid and pleasant. It was expected that craving would decrease significantly more after the eye movements compared to the control condition, and that this would be a lasting effect. It was also expected that the vividness of smoking-related images would decrease significantly more in the experimental condition than in the control condition. Finally, it was expected that the pleasantness of the image would decrease significantly more in the experimental condition than in the control condition.

Method

Participants

Prior to the experiment, a power analysis using the program G*Power calculated that the within-subjects design needed a minimum of 16 participants to achieve a power of .80. The study involved a total of 38 participants. Only participants who smoked at least 10 cigarettes per day, and who had not smoked at least one hour before the experiment, were included in the study. Based on these criteria, two individuals who had initially agreed to

participate were excluded. With the remaining 36 participants, a power of .997 was achieved. The study population consisted of 18 women and 18 men ranging in age from 18 to 37 years. Together they had a mean age of 22.3 years (SD = 3.3). They smoked an average of 14.9 cigarettes each day (SD = 4.55) and had an average of 3 hours of pre-study abstinence (SD = 3.85). The participants had an average smoking history of 6 years and 4 months (SD=3.64) and an average of 1.46 quit attempts (SD = 1.85) (Table 1).

Of the 36 participants, nine studied psychology (25%). Five participants indicated at the end of the experiment that they were familiar with EMDR (13.9%). Participants were recruited at ‘the Uithof’ of the University of Utrecht. Flyers were handed out and an announcement was placed on a notice board. The participants could earn €6, or one study credit, for taking part in the research.

Table 1: *Data participants (N=36)*

	M	(SD)
Age (years)	22,25	3,31
Cigarettes each day	14,90	4,55
Abstinence (hours)	3,13	3,85
Years smoking	6,36	3,64

Design

The study consisted of a 4 (time) x 2 (condition) within-subjects design with repeated measurements. The dependent variable was the experienced craving, and the independent variables were time and condition. The study consisted of two conditions. All participants took part in both conditions, and counter-balancing was used to control for order effects. By means of drawing lots it was determined in which condition the participants started. In the experimental condition with eye movements (EM), the participant was asked to follow the horizontal hand movements of the investigator with his or her eyes. The control condition consisted of the eyes fixated on a plain wall (Fix). Based on a random drawing, twenty participants were assigned to the EM-Fix sequence, and sixteen participants to the Fix-EM sequence. The experienced craving was measured at four different times in each condition: a baseline prior to

the induction of craving (M1), after generating craving (M2), immediately after performing the experimental manipulation or fixation (EM or Fix; M3) and finally, after recalling the starting image (M4) (see table 2). In addition to measuring the experienced craving, pleasantness and vividness were added as dependent variables in a 2 (time) x 2 (condition) design. These dependent variables were measured at M2 and M4 (see Table 2).

Conditions

During the study, a researcher was present in the examination room at all times. There were four experimenters, consisting of the four authors of this article. Dr. H. Hornsveld, an experienced EMDR therapist, had taught those conducting the present experiment the proper execution of hand movements. The horizontal hand movements were performed at a rate of one set per second with a plain wall as background.

Table 2: Measurements

	Condition 1*				Condition 2*			
	M1	M2	M3	M4	M1	M2	M3	M4
Craving	X	X	X	X	X	X	X	X
Pleasantness		X		X		X		X
Vividness		X		X		X		X

* Condition 1 and 2 can both be sequence EM-Fix or Fix-EM

Material

To measure the experienced craving, pleasantness and vividness, a Visual Analogue Scale (VAS) ranging from 0 to 100, was used. At 8 different moments for each condition, VAS scales were filled in (4 times for craving, 2 times for pleasantness and 2 times for vividness) (see Table 2). The following questions needed to be answered on a VAS scale: ‘How pleasant is this image for you right now?’ (pleasantness). ‘How vivid is this image right now?’ (vividness). ‘How much do you crave for a cigarette (or tobacco) right now?’ (craving).

Procedure

When participants entered the examination room they were welcomed, and they were told that all the information would be treated confidentially and that they had the right to stop at any time during the investigation. After a brief explanation of the study, participants were given the opportunity to ask questions and had to sign an informed consent form. Thereafter the participants were given a form on which age, gender, education and smoking behavior needed to be filled in. To determine the baseline of craving (M1) participants indicated the current craving for a cigarette on a VAS scale. By means of drawing lots, without replacement, the

participants were assigned to either the EM-Fix condition or Fix-EM condition. An attempt was made to increase the craving for a cigarette in five different ways. In previous studies, these techniques have been successful in increasing craving.

First, there was a period of abstinence for at least one hour prior to the study (May et al., 2010). Second, the participants expected that they would be able to smoke immediately after the examination (Droungas, Ehrman, Childress and O'Brien, 1995, Dols, van den Hout, Kindt & Willems, 2002). Participants had to draw a slip of paper to determine if they were allowed to smoke or not after the examination. This drawing was rigged to ensure that everyone got the confirmation that smoking would be permitted immediately after the examination. In the research area, several smoking cues were present: an ashtray, a lighter and a pack of cigarettes (Carter & Tiffany, 1999; Droungas et al., 1995). Subsequently, the participants were asked to pick their own cigarettes. Participants who didn't have their own cigarettes with them could take one from a pack of cigarettes on the table, so the availability of a cigarette was insured (Droungas et al., 1995). The participants were asked to hold the cigarette in the way they are used to, and also look at and smell the cigarette, a form

of in vivo exposure (Drobes & Tiffany, 1997). Participants were then asked to imagine a situation in the near future in which they desired a cigarette. This image was intensified by specific questions from the EMDR protocol (Jongh & Broeke, 2003), adapted to this particular study, and smoking (*What is currently the most pleasant picture of this image?, What makes this image so pleasant for you?, Where in your body is this feeling located (some suggestions: your mouth, head, lungs); While picturing the image in your mind, what emotion, for instance joy or relief, are you feeling right now?*). An important aspect of this modified protocol is that the personal mental representation is a positive flash forward, instead of the usual negative memories. Using the VAS scale, the current level of craving (M2) was determined. Also, the pleasantness and vividness of the mental representation was determined on a VAS scale. Afterward, it was explained that the personal smoking-related image is only a starting point from which anything can come to mind. The participants were asked to act as an observer of their own thoughts and to perceive what was going through them. (see Appendix). Then participants were asked, during 6 series of 24 sets (one second per set) to follow the horizontal finger movements of the investigator (EM) or to fixate at a point on the blank wall (Fix). The personal smoking-related image was used as the starting point of the first set. Immediately after exposure to either of these conditions, the VAS scale (M3) was again used to determine the current experienced craving. Next, each subject was asked to remember the personal smoking-related image that was used as a starting point, and again the VAS scales for craving, pleasantness and vividness were filled in (M4). As a neutral task between the two conditions, participants were asked to spend 10 minutes on a word puzzle (see Appendix). After this task, the participants took part in the other condition

in which the same procedure was repeated. It is important to mention that, in the second round, another personal smoking-related image was used.

Finally it was verified as to whether participants had an idea about the purpose of the study and whether they were familiar with EMDR. In conclusion, the participants were thanked for their participation, they were able to ask questions, and they were told the purpose of the study. They then either received six euros or were credited with one study participation hour.

Statistical analysis

The power analysis was done with the program G*Power version 3.1.2. The data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS), version 16.0. In this within-subjects design, a 4x2 ANOVA and a 2x2 ANOVA were used. Post hoc tests were performed using Paired-samples t-tests. On the control variables gender, education and familiarity with EMDR, the Bonferroni correction was applied.

Results

Inducing craving

Of particular interest was whether there would be an increase in craving from M1 to M2. The presence of craving allows the influence of different conditions to be investigated. The ANOVA reveals a significant main effect of time, $F(1.840, 64.387) = 16.679$, $p < .05$, $\eta^2 = .323$. Because the assumption of sphericity could not be assumed here, the Greenhouse-Geisser correction was used. The post hoc test shows that the craving in both the experimental condition ($t(35) = 4.125$, $p < .05$) and in the control condition ($t(35) = 4.988$, $p < .05$) significantly increased. On both M1 ($t(35) = 1.882$, $p = .068$) and M2, there is no difference in craving between the two

conditions ($t(35) = .213, p = .832$) (see Figure 1).

Hypothesis 1

As mentioned, there is a main effect for time $F(1.840, 64.387) = 16.679, p < .05, \eta^2 = .323$. It was expected that craving would decrease significantly more in the experimental condition, as compared to the control condition. The paired samples t-test shows a significant decrease in craving from M2 to M3 in the experimental condition ($t(35) = -3.690, p < .05$). The control group shows no significant increase or decrease in craving between M2 and M3 ($t(35) = -1.305, p = .201$). There is a significant increase between M3 and M4 in the experimental condition, $t(35) = 3.410, p < .05$. In the control group there is no significant difference between M3 and M4, $t(35) = .912, p = .368$ (see Figure 1). Because the current study included M4

to determine if the effect of eye movements on craving is permanent, M2

and M4 were also compared. Comparison of M2 and M4 shows that, in both the experimental condition ($t(35) = -1.182, p = .245$) and control condition ($t(35) = .757, p = .454$), there was no significant difference (see Figure 2).

In addition, the results show a significant interaction effect of time and condition $F(3, 105) = 6.278, p < .05, \eta^2 = .152$. The post hoc test shows that the craving at M3 in the experimental condition was significantly lower than in the control condition ($t(35) = 3.574, p < .05$). At M4, there appears to be no significant difference between both conditions $t(35) = .715, p = .479$ (see Figure 2).

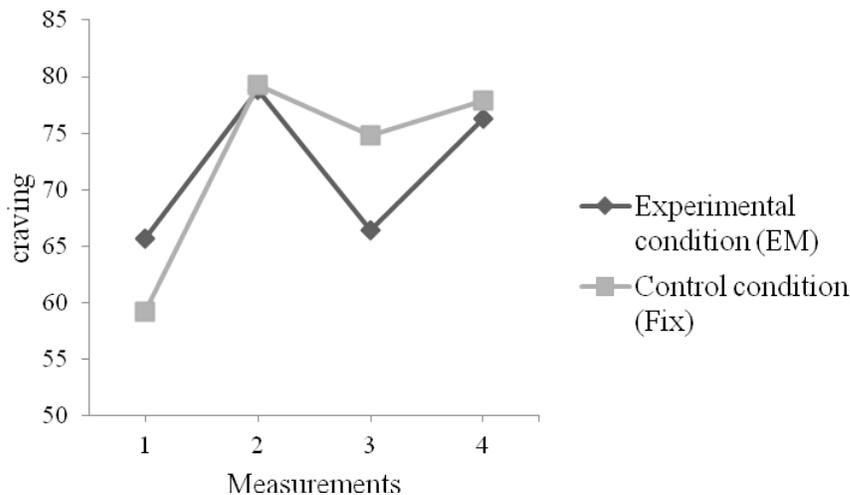


Figure 1: Course of craving between measurement points 1, 2, 3 and 4 for the experimental condition and control condition

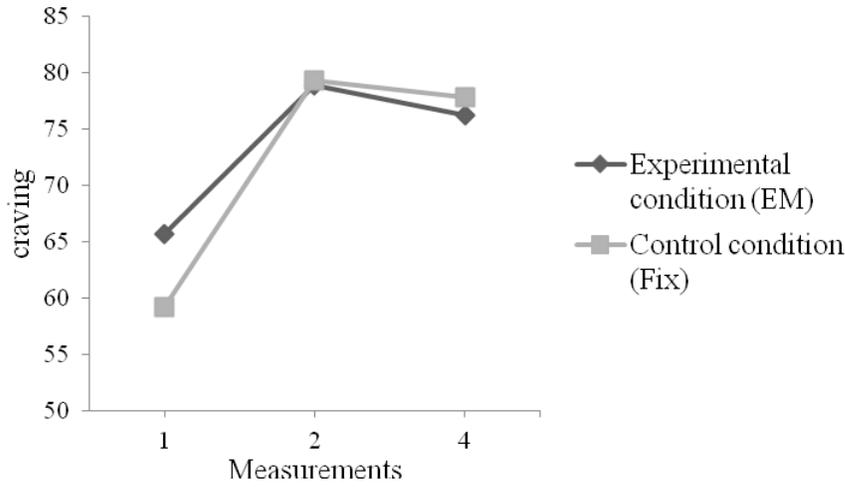


Figure 2: Course of craving between measurement points 1, 2 and 4 for the experimental condition and control condition

Hypothesis 2

It was also expected that the vividness of the smoking-related image would decrease significantly more in the experimental condition than in the control condition.

The results show that there was no main effect for time, $F(1,35) = .434, p = .514$. There was also no significant interaction effect of condition and time, $F(1,35) = 2.076, p = .158$ (see Figure 3).

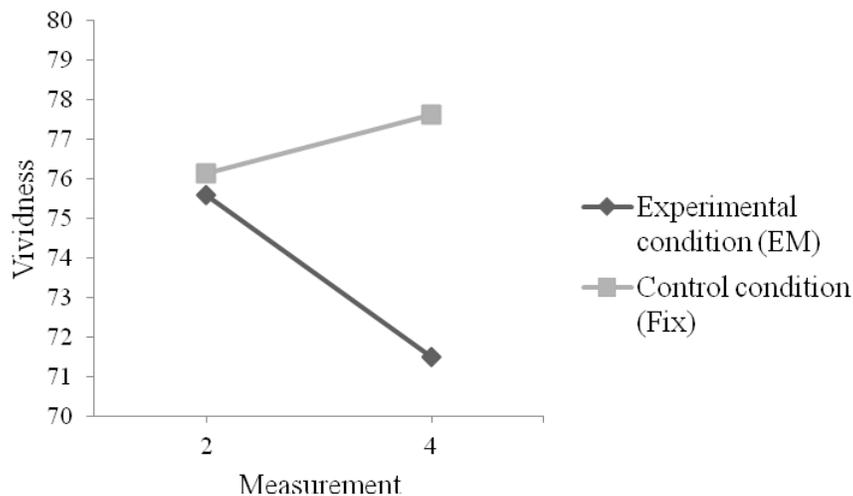


Figure 3: Course of vividness between measurement points 2 and 4

Hypothesis 3

Finally, it was expected that the pleasantness of the image would decrease significantly more in the experimental condition than in the control condition. The results show that there is no main effect for time, $F(1,35) = 1.597$, $p = .215$. There appears to be, however, a main effect of condition, $F(1,35) = 8.300$, $p < .05$, $\eta^2 =$

.192 η^2 . But this main effect is of no importance. In the present study, the interaction effect between time and condition is of particular interest. However, the ANOVA shows that there was no interaction effect between time and condition ($F(1,35) = .712$, $p = .405$) (see Figure 4).

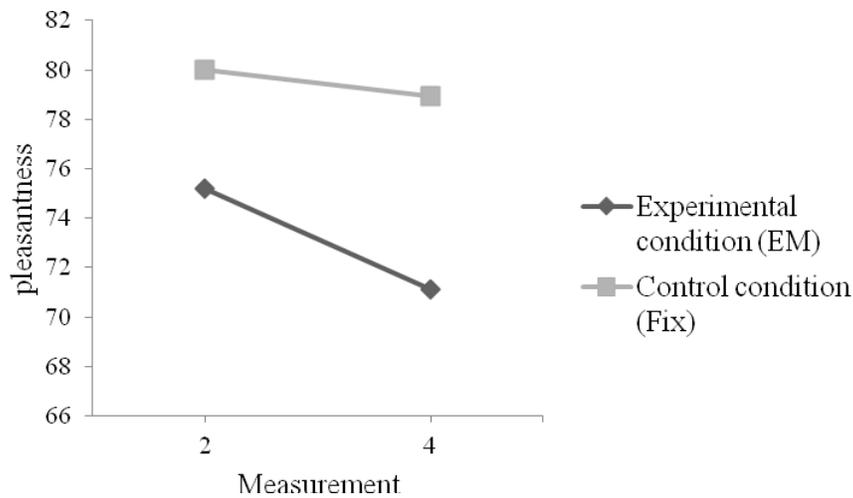


Figure 4: Course of pleasantness between measurement points 2 and 4

Correlations

In the experimental condition, a significant correlation was found between the decrease in craving and the decrease in pleasantness ($r = .530$, $p < .05$). This relationship is also shown in the control condition ($r = .638$, $p < .05$).

Control Variables

Influence of gender, familiarity with EMDR, and education on the dependent variables craving, vividness and pleasantness were determined. The results show that there is an interaction effect of gender on time for the dependent variable

agreeableness, $F(1, 34) = 8.531$, $p < .05$, $\eta^2 = .201$. After Bonferroni correction, this effect remained significant ($\alpha = .006$, $p = .006$).

In addition, correlations were determined between the number of cigarettes smoked per day, abstinence, number of quit attempts and number of years of smoking on the one hand, and the decrease between M2 and M4 of the dependent variables craving, vividness and pleasantness on the other hand. There is a significant correlation between the number of cigarettes smoked per day and the decrease in craving between M2 and M4 in

the experimental condition ($r = -.413$, $p < .05$). After removal of a notable outlier (number of cigarettes per day = 30) no significant correlation remained between number of cigarettes smoked per day and decrease in craving between M2 and M4 in the experimental condition ($r = -.032$, $p = .856$). There is also a significant correlation between the decrease in craving and time of abstinence in the control condition ($r = .367$, $p < .05$).

Discussion

In this study, craving was successfully induced. It was expected that craving would decrease more in the experimental condition, as compared to the control condition, and that this effect would be permanent. This hypothesis was partially confirmed, as craving immediately decreased after the sets of eye movements. However, when participants were asked again to visualize the smoking-related image, craving increased in the experimental condition. In the control condition, there was neither noticeable reduction of craving nor increase or decrease measured in craving after recalling the image. This suggests that the smoking-related image is not truly desensitized, and that the decrease in craving in the experimental condition was due to distraction.

Secondly, it was expected that vividness of the smoking-related image in the experimental condition would decrease more compared to the control condition. This hypothesis was not confirmed. After both eye movements and the control condition, there was no increase or decrease in vividness.

Finally, it was expected that pleasantness of the smoking-related image would decrease more compared to the control condition. This study indicates that there was no increase or decrease of

pleasantness in both conditions, which makes the hypothesis unconfirmed.

Desensitization of the smoking-related image using eye movements has not been successful in this study. However, there was a downward trend of craving, vividness and pleasantness noticeable after eye movements. These declines appear to be stronger in the experimental condition than in the control condition. For each trend, this is what would be expected, but the declines turn out to not be significant.

The results also revealed an interaction effect between gender and time on the dependent variable pleasantness. In men, the pleasantness of the smoking-related images increased in both the experimental condition and the control condition. In women the opposite occurred, with the pleasantness of smoking-related pictures decreasing in both conditions. To our knowledge, this effect of sex and time on pleasantness has not been demonstrated before. It is therefore assumed that this interaction effect can be attributed to chance. Furthermore we found a positive correlation between time of abstinence and the decrease of craving in the control condition. This would also be shown in the experimental condition, if this influence of time of abstinence exists. It is therefore assumed that this finding can be attributed to chance.

A positive correlation between the decrease in pleasantness and the decrease in experienced craving was found in both the experimental and the control conditions. The direction of this relationship is unclear. If the decrease in pleasantness is the cause of the decrease in craving, it may be interesting to consider interventions focusing on reducing pleasantness. More research is necessary to demonstrate the direction of this relationship.

In this study, a decrease in the level of craving can be seen immediately after completing the intervention. This decrease was not maintained when the original

image was recalled. Research in which a restoration of the initial level of craving was found after taxing the visuospatial working memory was performed by Versland and Rosenberg (2007). After in vivo exposure to a lighted cigarette, participants were asked to imagine a beach for two minutes. During the intervention, the level of craving decreased, but this reduction was not found in the post-test. This recovery may be explained by the short duration of the intervention of both this study and the study of Versland and Rosenberg (2007). The duration of these interventions were respectively 144 and 120 seconds. In the studies of Holmes, James, Coode-Bate and Deeproose (2009) participants played the computer game Tetris for ten minutes after watching a film with traumatic images. This visuospatial working memory load resulted in a reduction of the number of intrusive flashbacks, which after one week were still significantly reduced. Such a long-term effect was again found in similar research by Holmes, James, Kilkenny and Deeproose (2010). In the previously discussed study of Hase, Schallmayer and Sack (2008) participants twice underwent a one-hour EMDR session. The results of this study showed that craving for alcohol was decreased immediately after the examination, and at a follow-up measurement after one month. The studies mentioned above suggest that the duration of EMDR sessions affects the continued decrease in craving. The lasting effect of eye movements on craving for cigarettes has not yet been examined. Future research should reveal whether this effect can be seen in an intervention of longer duration. It would also be interesting to investigate whether a dose-response effect occurs when visuospatial tasks with different levels of load are executed to reduce craving. Interestingly, the degree of vividness and pleasantness has not decreased after undergoing the condition with eye movements. Previous research

repeatedly demonstrated the effectiveness of eye movement on vividness and pleasantness of both unpleasant and pleasant memories (eg van den Hout et al., 2001). Also the effectiveness of eye movements on vividness and pleasantness of flash forwards has been shown (Engelhard et al., 2010). However, the study of Engelhard et al., (2010) was only conducted with unpleasant flashforwards. To date, there has been no research on the effectiveness of eye movements on pleasant flash forwards. Possibly, the combination of pleasant images and flash forwards play a role in the small decrease of vividness and pleasantness in this study. Future research could examine this.

The extent of craving that was experienced by the participants was measured with a VAS scale. The Elaborated Intrusion Theory of Desire describes craving as a cycle in which smoking-related cues from the environment capture one's attention and give rise to the retrieval of relevant information about smoking in ones memory. Based on this EI-theory, a VAS scale may simply be inadequate for measuring the different aspects of craving. Statham et al. (2011) have developed a measuring instrument, the Alcohol Craving Measure (ACE), designed on the basis of the EI theory. Through factor analysis, three factors underlying craving have been identified: 'imagery', 'intensity' and 'intrusion.' The validity of this questionnaire seems promising. A questionnaire based on the EI-theory measuring craving in smoking addiction does not yet exist. Future research could focus on developing such a questionnaire, which could prove to be a better measurement instrument to measure craving than a VAS scale.

Next to the short duration of the intervention, another limitation in this study is the use of mainly young students who were not actively trying to quit smoking. Whether the results of this

group can be generalized to a population that is trying to quit smoking is not clear. The application of eye movements is primarily designed for this latter population because smoking cessation, despite current interventions, appears difficult.

The current study has shown that the additional post-test is very important. Through these measurements, it became clear that the effect was not permanent. The absence of a post-test would have given an incomplete picture of the effect of eye movements. In

addition, the study stayed as close as possible to an EMDR intervention by letting the participants imagine a personal mental image. This study is innovative in the research of eye movements, because it is one of the first that focused on the application of eye movements to treat smoking addiction. In addition, an attempt has been made to desensitize pleasant flash forwards using eye movements, research that until now had not yet been conducted.

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